NMME Expansion Project Update

Project Goal:

- Enhance the NMME reforecast data with high-frequency data
- Evaluate forecast capabilities and predictabilities of high-impact weather based on the existing NMME model data
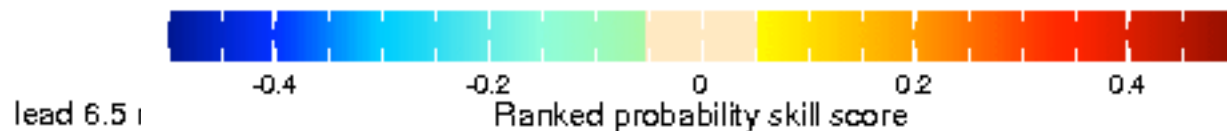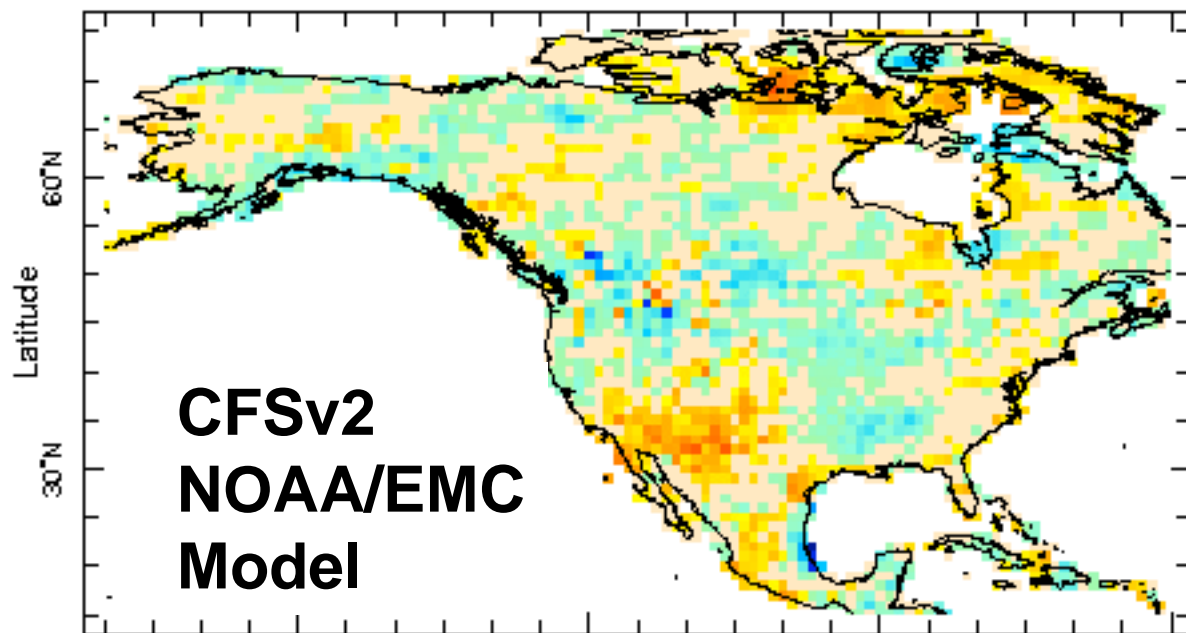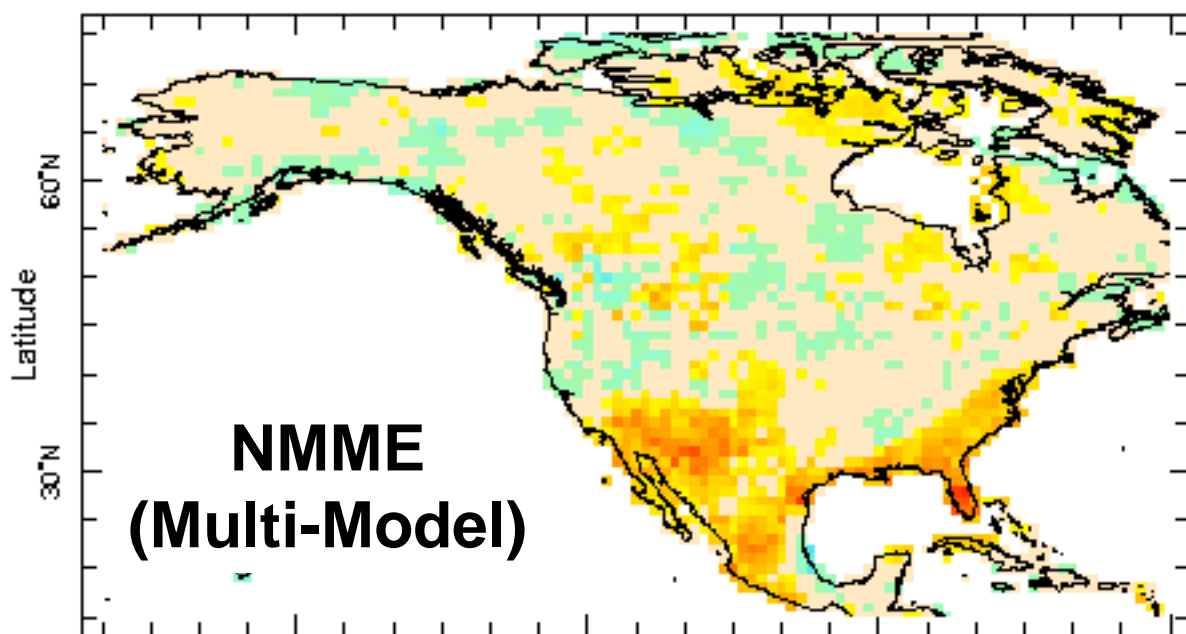
Three sub-projects:

- Severe weather environmental factors in NMME
- NMME-based hurricane predictions
- NMME Phase-II data

Jin Huang
Feb. 09, 2016

DJF **Precipitation Forecast Skill (RPSS)**

NMME (Multi-Model)

6-Month Lead Forecast (1 July Initial Conditions)

CFSv2 NOAA/EMC Model

lead 6.5

-0.4   -0.2   0   0.2   0.4

Ranked probability skill score

JJA Precipitation Forecast Skill (RPSS)
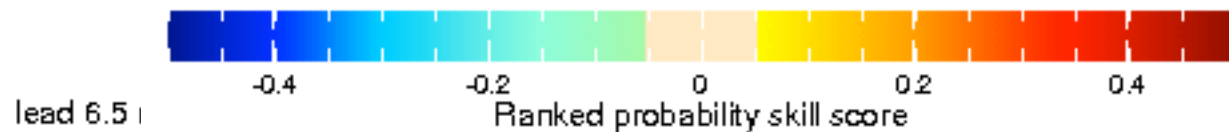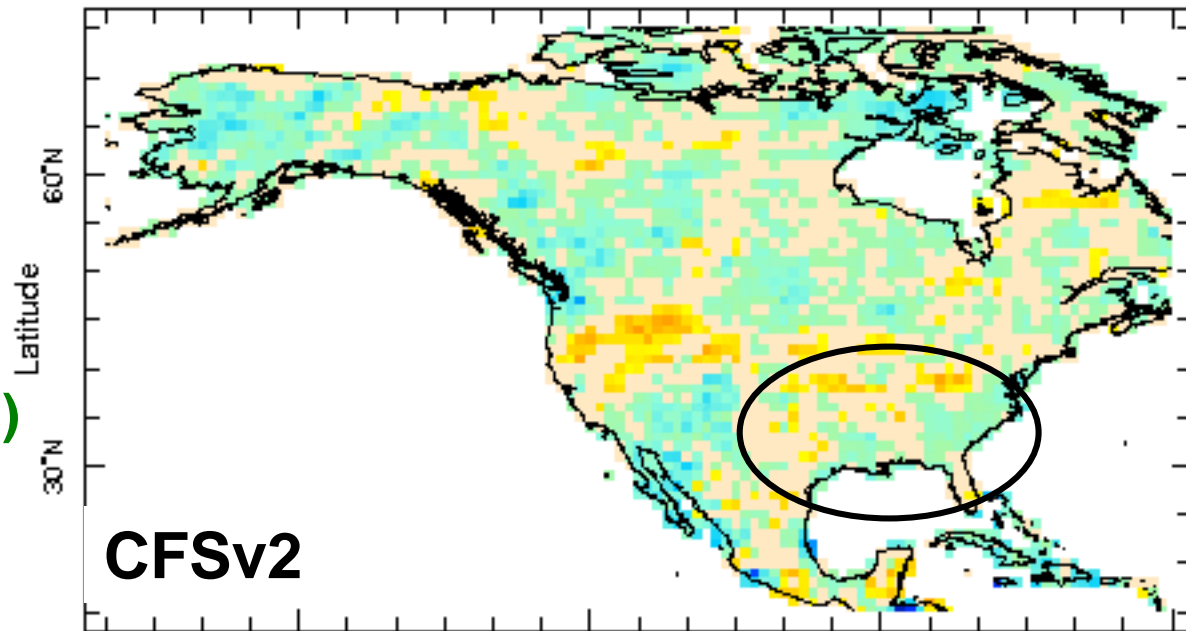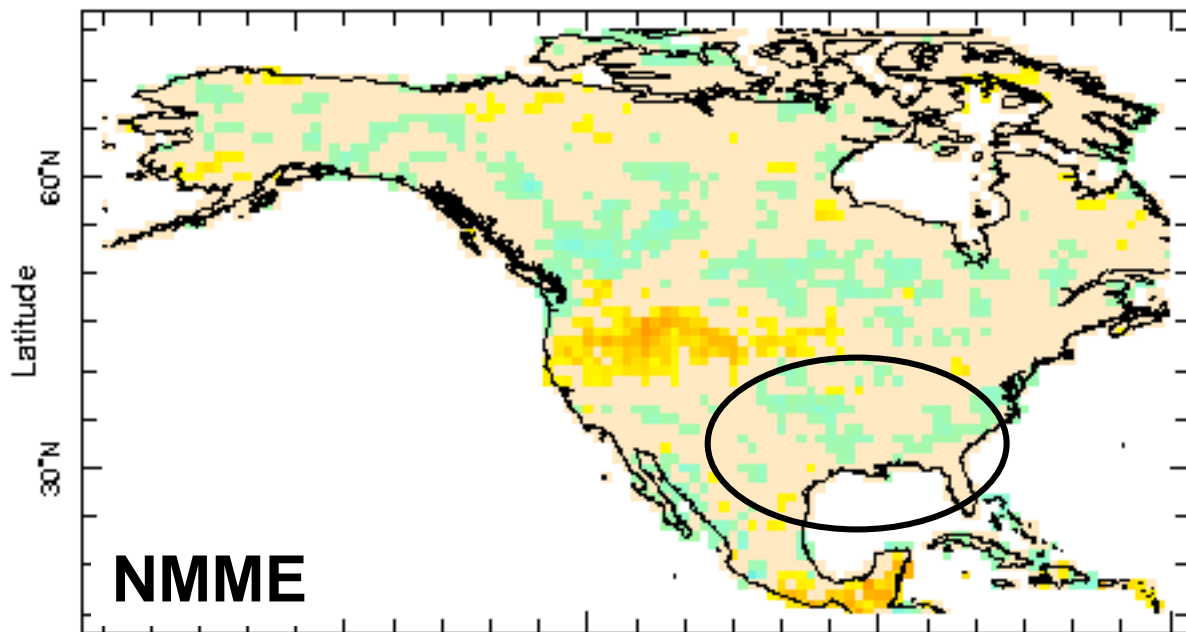
NMME

**6-Month Lead Forecast
(1 January Initial Conditions)**

CFSv2

lead 6.5

Ranked probability skill score

-0.4   -0.2   0   0.2   0.4

1. Assess severe weather environmental factors using NMME data
(PI: Kirtman)

- **Key Question:**
  - Given the difficulty of predicting warm-season precipitation, **can we predict changes in the likelihood of a tornado outbreak on seasonal time scales?**

- **Approach:**
  - Convective Available Potential Energy (CAPE)
  - NMME model capabilities to simulate CAPE climatology
    - NCAR/CCSM4, NCEP/CFSv2,
    - North American Regional Reanalysis (NARR)
  - CAPE predictability from environmental factors
    - ENSO teleconnection
    - Gulf of Mexico SST

CCSM4 retrospectives forecast CAPE monthly climatology compared with observations (NARR)
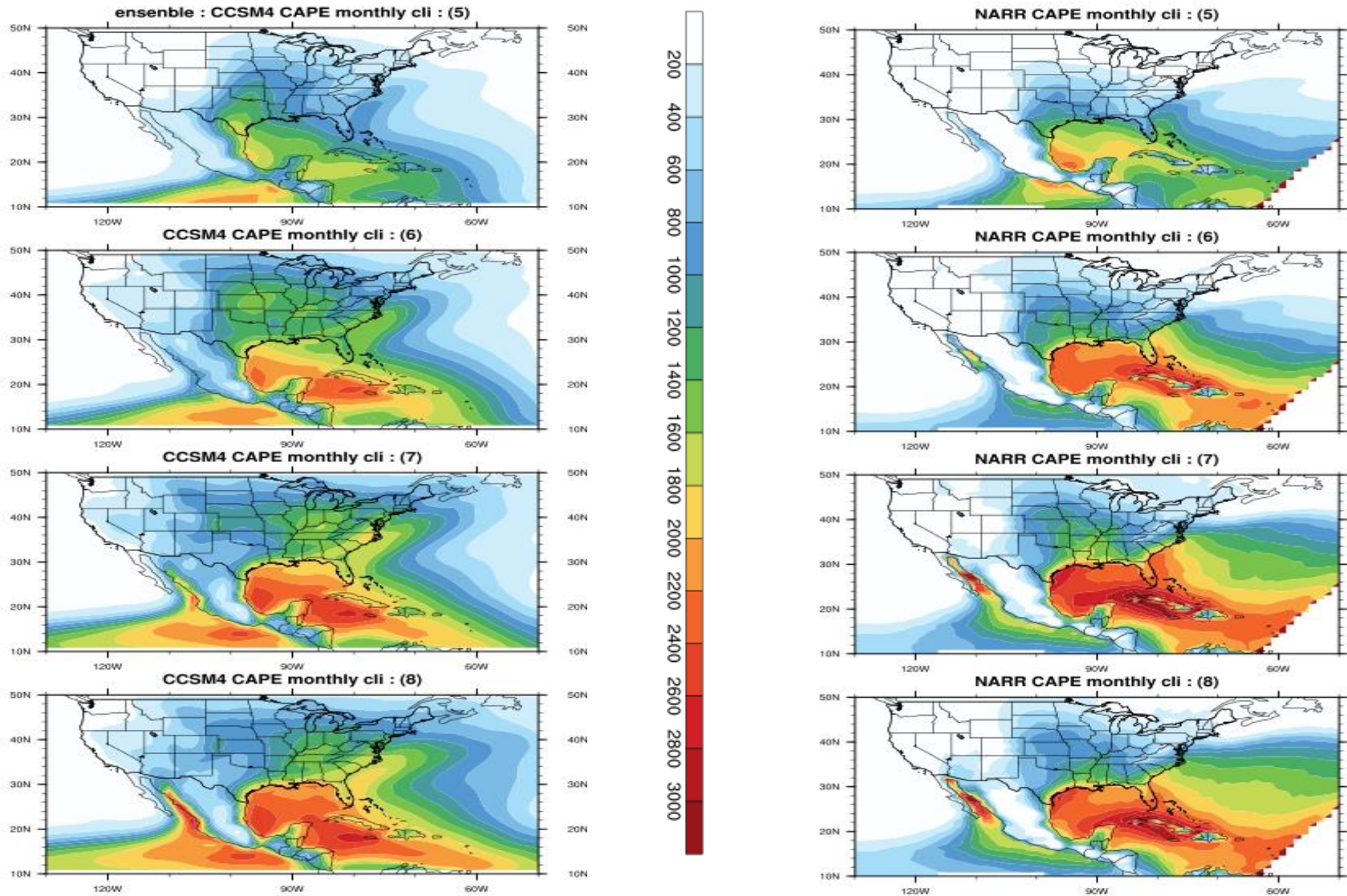
NARR MJJ Accumulated Daily CAPE La Nina Composite
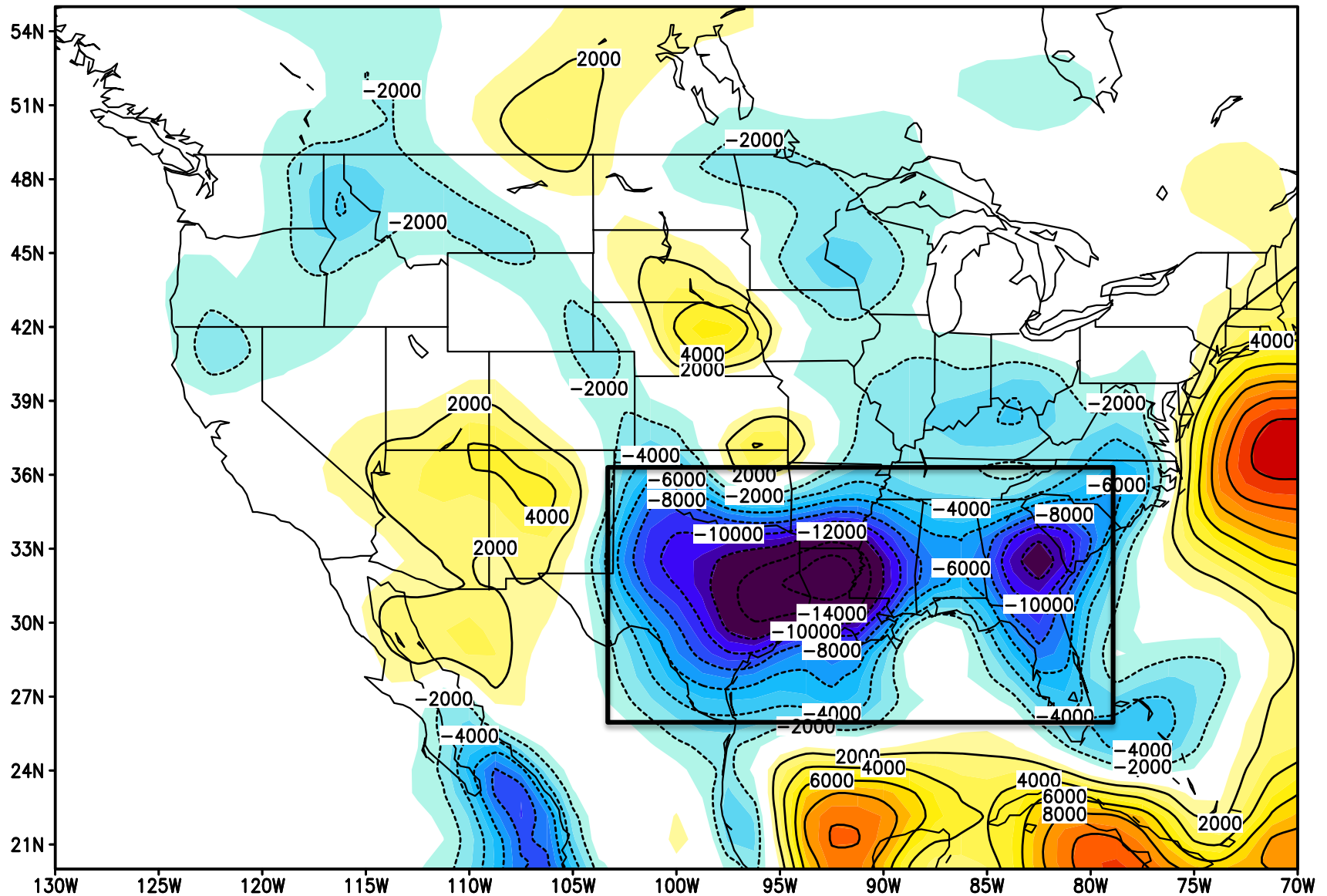
NARR MJJ Accumulated Daily CAPE El Nino Composite

Forecast MJJ Accumulated Daily CAPE El Nino Composite
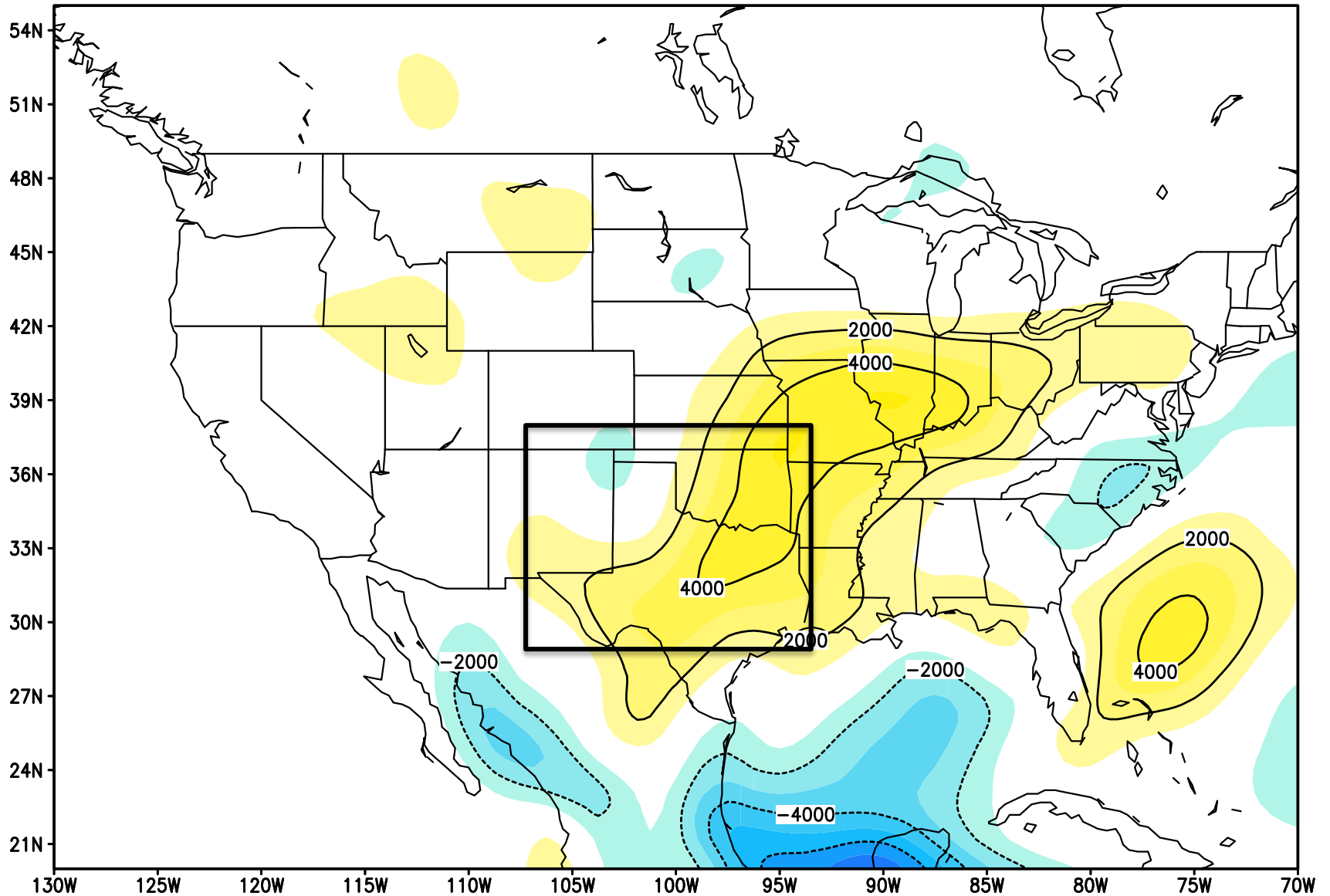
CAPE Composite Maps
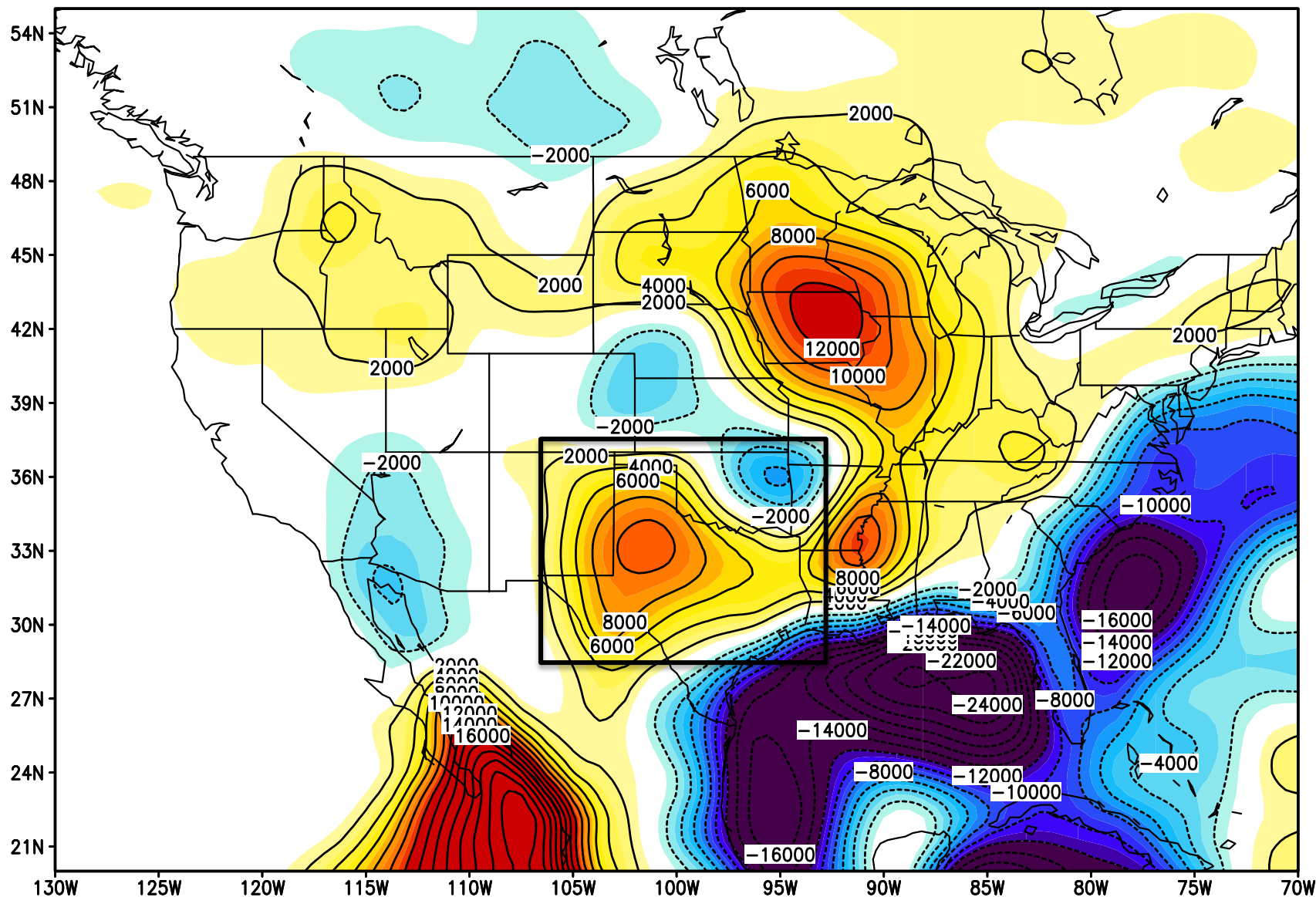# based on Gulf of Mexico SSTA
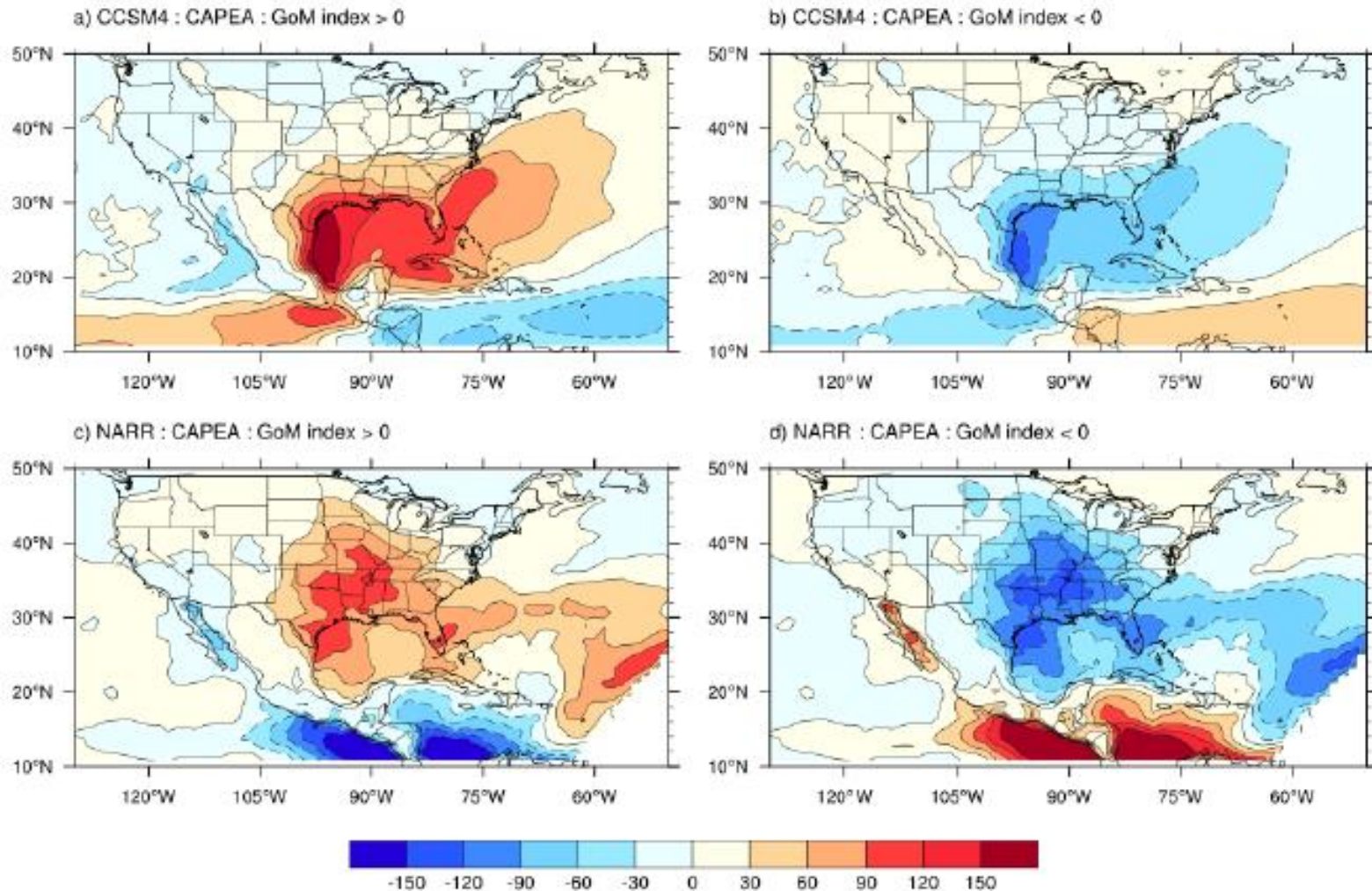
2. NMME-based Hurricane Hybrid Prediction System (PI: J. Schemm, D, Harnos and H. Wang)

- **Task:**
  - The goal of this sub-project is to provide an additional forecast tool for CPC's Atlantic Hurricane Season Outlook

- **Approach:**
  - A Multiple regression relationship established between the observed Atlantic hurricane season activity and predicted circulation variables.
    - Predictors: Forecast Wind shear for ASO and preseason observed N. ATL SST
    - Predictands: Season total number of named storms and hurricanes, and accumulated cyclone energy index

- **Hindcast data:**
  Period; 1982-2010
  IC Months; April, May, June and July
  Models evaluated: CanCM3, CanCM4, CFSv2 and CCSM4

- **Real time prediction**: 2015 hurricane season

N. Atlantic Hybrid Model: April Initial Conditions

1982-2010 Cross-Validation

Correlations

	CanCM34 (20)	CCSM4 (10)	CFSv2 (24)	NMME (3)
T. Storms	0.59	0.50	0.49	0.56 (2nd)
Hurricanes	0.44	0.43	0.52	0.49 (2nd)
M. Hurricanes	0.46	0.35	0.41	0.43 (2nd)
ACE	0.54	0.53	0.57	0.57 (t-1st)

RMSE

	CanCM34 (20)	CCSM4 (10)	CFSv2 (24)	NMME (3)
T. Storms	4.05	4.10	4.15	3.13 (1st)
Hurricanes	2.86	2.88	2.70	2.33 (1st)
M. Hurricanes	1.73	1.83	1.77	1.39 (1st)
ACE	55.99	56.92	55.04	47.49 (1st)

N. Atlantic Hybrid Model: July Initial Conditions

1982-2010 Cross-Validation

Correlations

	CanCM34 (20)	CCSM4 (10)	CFSv2 (24)	NMME (3)
T. Storms	0.70	0.59	0.59	0.66 (2nd)
Hurricanes	0.68	0.62	0.65	0.70 (1st)
M. Hurricanes	0.60	0.53	0.61	0.61 (t-1st)
ACE	0.72	0.69	0.65	0.72 (t-1st)

RMSE

	CanCM34 (20)	CCSM4 (10)	CFSv2 (24)	NMME (3)
T. Storms	3.56	3.84	3.86	2.90 (1st)
Hurricanes	2.30	2.49	2.39	1.75 (1st)
M. Hurricanes	1.52	1.63	1.52	1.21 (1st)
ACE	45.95	48.17	50.59	38.38 (1st)

NMME Hybrid prediction for 2015 ; April ICs
Predictors: Predicted ASO shear anomaly and observed JFM NATL SST

	Hurricanes	Tropical Storms	M. Hurricanes	% Median ACE
CanCM3 (10)	3 (2-5)	6 (2-10)	1 (0-2)	46 (3-89)
CanCM4 (10)	2 (0-3)	4 (2-6)	0 (0-1)	14 (0-43)
CFSv2 (32)	5 (4-7)	10 (8-12)	2 (2-3)	85 (52-117)
CCSM4 (10)	5 (4-5)	9 (8-10)	2 (2-2)	77 (63-92)
NMME (4)	3 (0-6) 4(obs)	6 (1-12) 12(obs)	1 (0-3) 2(Obs)	37 (0-114) 64(O)

	Hurricanes	Tropical Storms	M. Hurricanes	% Median ACE
CanCM3 (10)	91 6 3	94 4 2	86 5 9	90 5 5
CanCM4 (10)	95 3 2	97 2 1	86 6 8	93 3 4
CFSv2 (32)	65 21 14	60 33 7	60 19 21	60 30 10
CCSM4 (10)	85 11 4	84 13 3	83 7 10	87 11 2
NMME (4)	93 4 3	94 5 1	90 4 6	92 5 3

%Below normal   %Near normal   %Above normal

NMME Hybrid Prediction for 2015; July ICs

Predictors: Forecast ASO shear anomaly and observed AMJ NATL SST

	Hurricanes	Tropical Storms	M. Hurricanes	% Median ACE
CanCM34 (20)	1 (0-2)	2 (0-4)	0 (0-1)	6 (0-22)
CFSv2 (32)	7 (5-8)	12 (10-13)	3 (2-3)	116 (90-143)
CCSM4 (10)	3 (2-4)	7 (6-8)	1 (1-2)	35 (16-57)
NMME (3)	4 (2-5) 4(Obs)	7 (5-9) 10(Obs)	1 (1-2) 2(Obs)	52 (35-74) 57(O)

	Hurricanes	Tropical Storms	M. Hurricanes	% Median ACE
CanCM34 (20)	95 5 0	95 5 0	95 5 0	100 0 0
CFSv2 (32)	3 38 59	3 69 28	3 26 71	3 51 46
CCSM4 (10)	90 10 0	90 10 0	90 10 0	90 10 0
NMME (3)	63 18 19	63 28 9	63 14 23	64 21 15

%Below normal   %Near normal   %Above normal

3. NMME Phase-II Data: Status

1. Recent Highlights
   - GEOS-5 Daily Data complete
   - CFSV2 6hr Data Complete
   - FLOR-B, CanCM3, CanCM4 include Sea Ice fields (concentration, thickness)
2. Upcoming Products
   - CFSV2 Daily ETA Mar 31, 2016
   - CESM1 Daily ETA April 30, 2016
3. Ocean Monthly
   - CCSM4 Monthly (75% complete, ETA Mar 15, 2016)
   - GEOS-5 Monthly (60% complete, ETA Mar 31, 2016)
4. Archive Use and Metrics
   - 750K Files/300TB of raw data
   - 10 TB Average monthly downloads
   - 100 Organizations accessing NMME data (past 3 months)
5. Data Access and Documentation
   - Data Archive: https://www.earthsystemgrid.org/search.html?Project=NMME
   - Documentation: https://www.earthsystemcog.org/projects/nmme/
6. Future Direction
   - Update all NetCDF File Metadata to full CF Compliance
   - Process all files to NetCDF4 with compression
   - Enable OpenDAP services

NMME Phase-II Data Archive Overview: Feb 5, 2016
Archive Data by Variable and Model

	CCSM4		CESM1	CFSV2		CanCM3	CanCM4	FLORB	GEOS5
Variable	**Daily**	**3hr**	**Daily**	**Daily**	**6hr**	**Daily**	**Daily**	**Daily**	**Daily**
TAS	⊘	✓	**EX**	EX	✓	✓	✓	✓	✓
TA	✓	⊘	**EX**	**EX**	✓	✓	✓	⊘	✓
TASMIN	✓	⊘	**EX**	**EX**	✓	✓	✓	✓	✓
TASMAX	✓	⊘	**EX**	**EX**	✓	✓	✓	✓	✓
PR	⊘	✓	**EX**	**EX**	✓	✓	✓	✓	✓
PSL	✓	⊘	**EX**	**EX**	✓	✓	✓	⊘	✓
UA	✓	✓	**EX**	**EX**	✓	✓	✓	⊘	✓
VA	✓	✓	**EX**	**EX**	✓	✓	✓	⊘	✓
G	✓	⊘	**EX**	**EX**	✓	✓	✓	⊘	✓

✓   Complete

EX   Expected (not yet published)

⊘   Not Expected

?   Status not yet evaluated or unknown

- CFSV2 daily complete Mar, 2016
- CESM1 daily complete May, 2016

Summary

- **The NMME-HIWPP Project enhanced and leveraged existing NMME effort**

- **Evaluation of extreme weather environmental factors in NMME models**:
  - NMME model reforecasts capture the observed CAPE climatology well
  - Accumulated CAPE shows some modest predictability based on NMME forecasts (e.g., ENSO, Gulf of Mexico SST)

- **NMME-based hurricane forecasts**:
  - The NMME-based hybrid system exhibits considerable skill in predicting the ATL hurricane season activity. The NMME system outperforms the single model forecasts in most categories and the system will be improved further with additional members.
  - Real-time predictions based on this hybrid system were provided to the NOAA HSO forecasters in April 2015 for the May Outlook and in July 2015 for the August Outlook Update. The season was predicted both times as below normal that has been well verified.

- **Great progress in NMME Phase-II daily data development**

Quick Update on NMME Activities

- **The NMME seasonal forecast system is in operation;**

- **The protocol for the NMME sub-seasonal forecast experiment has been developed**

- **Ongoing and future projects contributing to NMME**
  - The proposals to the NOAA/CPO FY16 call for MAPP-CTB projects to conduct a sub-seasonal climate prediction experiment have been reviewed;
  - Ongoing MAPP grants projects on NMME analysis and applications